The Control of Cereal Smuts in Washington

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THE CONTROL OF CEREAL SMUTS IN WASHINGTON

THE NATURE OF SMUTS

The smut diseases are caused by microscopic fungi which live in various seed plants from which they steal the food necessary for their support. In adopting this parasitic mode of life, the smut fungi bring about various disturbances in the life of their hosts, the plants on which they live, thus being the cause of specific infectious diseases. The smut diseases are not confined to our cereal crops, but affect many other wild or cultivated grasses, and also a lesser number of seed plants belonging to unrelated families.

The smuts of cereals are especially destructive since in most cases they destroy either the individual grains or the entire head, panicle or ear. The smut fungi develop within the interior of their hosts, and give little or no external evidence of their presence until the appearance of the black masses which result when the normal parts are destroyed. The black powdery dust which appears in the evidently smutted parts consists of myriads of minute reproductive bodies or "spores" which play the same part in the life of the smut fungi that seeds do in the life of higher plants. All infections of our crop plants with smut orginate either from spores carried on the seed, blown to flowers of normal plants or mixed with the soil of our fields.

Each cereal is affected with one or more distinct kinds of smut, agreeing in many points, but differing in important details of life history, so that different control measures must be adopted. The three important groups are as follows:

Group 1. This includes bunt or stinking smut of wheat, the two smuts of oats, the covered smut of barley and the kernel smut of sorghum. In all of these diseases the smut spores are carried on

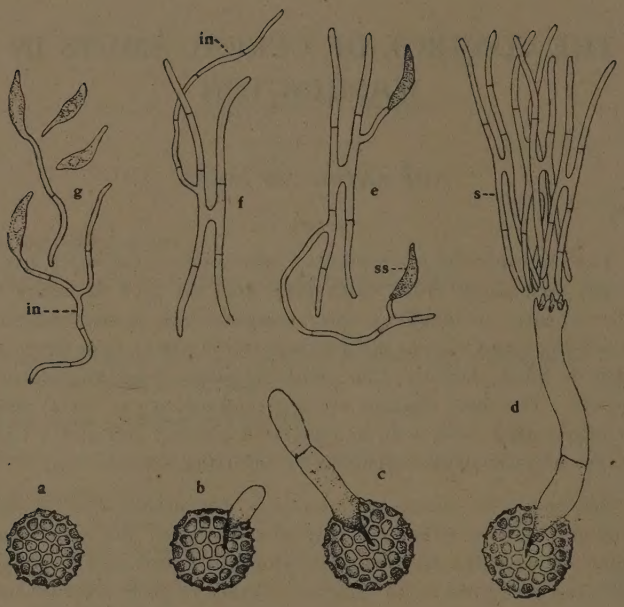

Fig. 1. Various stages in the germination of spores of stinking smut of wheat (a) Spore surface showing characteristic ridges; (b) spore in early stage of germination with young smut plant protruding from the ruptured spore wall; (c) a later stage in the formation of the smut plant; (d) mature smut plant with a tuft of H-shaped sporidia (s) borne at its summit; (e) separate sporidium which has produced secondary sporidia (ss); (f) a separated sporidium which has given rise directly to an infection thread (in); (g) several secondary sporidia which have started to germinate or have produced infection threads. (From Washington Agri. Exp. Station Bulletin 126).

the seed, and so infect the crop only during the seedling stage. In the bunt of wheat, spores in the soil may also cause infection. Because of the way in which the disease is carried, **seed disinfection with chemical poisons or fungicides will give either complete or partial control.** By seed disinfection we mean the killing of the spores on the surface of the seed grain.

Group 2. This includes the loose smut of wheat and the loose smut of barley. In these diseases the smut fungus is not carried in the spore form on the surface of the seeds, but exists in the in-

terior in a dormant vegetative form and is ready to resume growth when the young seedlings begin their development. The initial infection occurs during the blossoming stage. These loose smuts may also be controlled by a seed disinfection, but different methods must be employed than for Group 1.

Group 3. This includes common corn smut and the head smut of corn and sorghum. In common corn smut the seedlings are not infected from seed-borne spores but all the smut tumors are localized on aerial parts and originate from wind-blown spores which are carried up from the soil. In head smut the infection takes place in the seedling stage, but the spores are in the soil rather than being carried on the seed. These peculiarities in the life history make seed treatment of no value in the control of these smuts.

TABULATION OF CEREAL SMUTS PRESENT IN WASHINGTON

Crop	Common name of smut	Scientific name of smut	General effect	Time of infection
Wheat	Bunt, or stinking smut or low smut.	Tilletia tritici*	All or part of the grains replaced by "smut balls."	Seedlings infected from seed-borne spores or from contaminated soil
	Loose smut.	Ustilago tritici.	All parts of head destroyed except central axis and forming a loose powdery mass.	Seed of normal plants infected at blossoming time by wind-blown spores.
Oats	Covered or kernel smut	Ustilago levis.	Grain replaced by firm smut masses inclosed by the translucent glumes.	Seedings infected from seed-borne spores, scattered at threshing time.
	Loose smut.	Ustilago avenae	All parts of panicle destroyed and forming a loose powdery mass.	Same as for covered smut but spores are disseminated previous to harvest.

*The smooth-spore bunt or **Tilletia levis** is rare in Washington but is similar in appearance and effects.

Barley	Covered smut.	Ustilago hordei.	Grains and surrounding parts destroyed but smut masses more or less completely covered by translucent membrane.	Seedlings infected from seed-borne spores.
	Loose smut.	Ustilago nuda	All parts of head destroyed except central axis and forming a loose powdery black mass.	Seed of normal plants infected at blossoming time by wind-blown spores.
Corn	Common smut.	Ustilago zeae	Smut tumors on any aerial parts but very common on ears or tassels. Covered with whitish membrane when young.	Localized infections from time plants are knee high to approaching maturity. Not carried on seed.
	Head smut	Sphacelotheca reiliana	Smut masses only on ears or tassels; not covered with a whitish membrane.	Seedlings infected from contaminated soil.
Sorghum	Kernel smut	Sphacelotheca sorghi	All or part of the grains in a head replaced by "smut balls."	Seedlings infected from seed-borne spores.
	Head smut	Sphacelotheca reiliana	Smut masses only on heads, which are completely destroyed	Seedlings infected from contaminated soil.

BUNT OR STINKING SMUT OF WHEAT

Bunt can not be controlled by a single practice but rather by the combined use of various methods.

Practice crop rotation with the elimination of summer fallow in regions which do not require fallow for the conservation of mois-

Fig. 2. Bunt or stinking smut of wheat. (a) Smutted and normal heads of Winter Fife; (b) smutted and normal heads of Hybrid 108. (From Washington Agri. Exp. Station Bulletin 126).

ture. Wheat following wheat is likely to be smutty if the previous crop was smutty. Winter wheat on summer fallow is likely to be smutty because of the soil contamination from wind-blown smut. This wind-blown smut does not live through the winter, so that

carefully treated spring wheat planted in summer fallow should be free from smut.

Use clean seed. Do not use visibly smutted seed where it is possible to obtain clean stock. If wheat showing unbroken smut balls must be used for seed purposes, it should be thoroughly cleaned by a mill or grader to remove as much of the smut as possible.

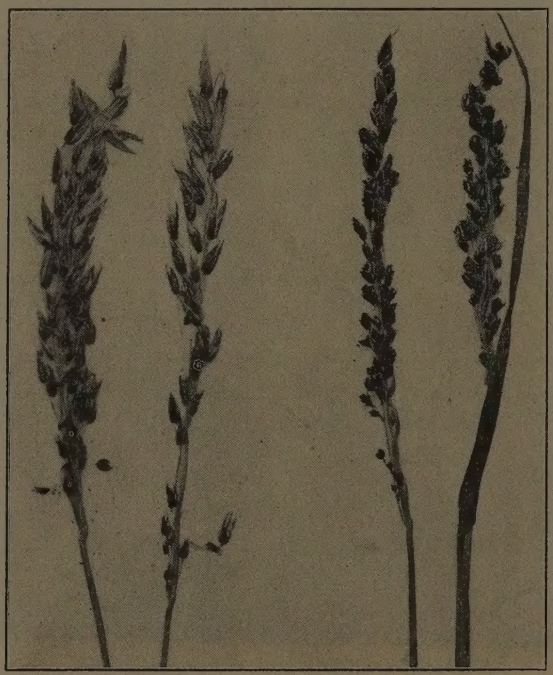

Fig 3. Covered smut of oats Loose smut of oats

Disinfest the seed by using formaldehyde or bluestone by either the sack or open tank method or copper corbonate dust. **Bluestone is to be preferred over formaldehyde for all fall seedings since it lessens the infections from smut in the soil.** Either fungicide may be

used for spring seeding. Never omit the treatment of visibly smutted seed. Visibly clean seed should be treated unless it has been analysed and found to be either smut-free or carrying so little smut as to make seed disinfection unprofitable. Analyses of seed for smut can be supplied by sending samples to the State College of Washington Experiment Station, Pullman. Marquis rarely contains sufficient smut to justify the expense of seed disinfection.

Cultural practices which are known to prevent smut or reduce the percentage of infection should be followed as closely as possible. The most important facts to keep in mind are:

(a) Early seeding either before the "smut shower" or at least before the fall rains begin will give either a smut-free crop or a low percent of infection. Seedings from August 15 to September 1 have given very satisfactory results for both yield and freedom from smut, and are worthy of trial. Early seeded fields should be pastured to lessen the danger of winter killing.

(b) Late fall seeding gives less smut than normal seasonal plantings but is more susceptible to winter injury.

(c) The maximum amount of smut will be found in wheat seeded during late September or early October.

(d) Re-plowing of summer fallow reduces the amount of smut if seeding follows immediately.

(e) Wheat following corn or peas generally produces less smut than wheat on summer fallow, since the preparation of the ground buries some of the wind-blown smut.

(f) Shallow seeding gives less smut than deep seeding.

(g) Seeding in the dust will give less smut than planting soon after rains begin, but the reliability of seeding in the dust must be determined for the different localities.

Make use of resistant varieties if there are any suited to your locality. Marquis is the most resistant spring variety in general use. Under conditions for maximum infection six different strains of Marquis produced 3.73-26.84 percent of smut as compared with 64-94 per cent for susceptible varieties like Bluestem, Early Baart or Jenkins' Club.

Among winter wheats, Turkey Red and Kanred are very resistant as compared with Red Russian, Winter Fife, Bluestem or any of the club varieties. It is hoped that the selection and breeding work now in progress will yield other resistant or immune varieties. Susceptible varieties with a high yielding capacity may be better than less productive resistant varieties. This is notably true in the case of Hybrid 128, a variety very susceptible to bunt, but with a record of high yields.

COVERED AND LOOSE SMUTS OF OATS, COVERED SMUT OF BARLEY, AND KERNEL SMUT OF SORGHUM

These three smuts may be controlled by essentially the same practices:

Fig. 4. Covered smut of barley

Use clean seed. In the covered smut of oats, the common kind in Washington, and in the covered smut of barley, the smut masses break up in the threshing operation, so that heavily smutted seed will show many fragments of smut masses mingled with the seed as well as loose spores lodged on the surface of normal grains. If seed showing these broken fragments of smut masses must be used it should be cleaned with a mill or grader previous to disinfection.

Disinfect the seed unless it is known to be free from smut, or highly resistant. Use formaldehyde, employing whichever method is best suited to the facilities available. Do not use bluestone, as it causes heavy reduction in germination.

Use resistant or immune varieties of oats if any are adapted to local conditions.

Classification as to Disease Resistance.

Immune or highly resistant	Moderately susceptible	Very susceptible
Burt	Swedish Select	Chinese Hulless
Texas Red	Sparrowbill	Large Hulless
Kherson	Abundance	Sandwich
	Banner	Sixty Day
	Red Rust Proof	Grey
		Potato

Those varieties listed as immune will rarely justify the expense of seed disinfection.

Early seeding of oats gives the minimum amount of smut.

Treatment.

Oats: Loose smut.

Sack, sprinkle (1 pt. to 40 gallons) or dry method.

Covered smut.

Sack or open tank method (1 pt. to 40 gallons).

Barley: Covered smut.

Sack or open tank method (1 pt. to 40 gallons).

Sorghum: Kernel smut.

Sack or open tank method (1 pt. to 30 gallons).

THE LOOSE SMUTS OF WHEAT AND BARLEY

Both of these smuts are present in Washington fields, generally

Fig. 5. Loose smut of barley. (From Wash. Extension bulletin 43)

showing less than one per cent of the heads smutted, which does not seem to be a sufficient amount to justify the expense of seed disinfection. They can not be controlled by the chemical steps but require the more laborious hot water treatment*. This method of seed disinfection and the growing of a seed plot for the production of smut-free seed for the main crop, is the method of control in regions where the disease is severe.

COMMON SMUT OF CORN AND HEAD SMUT OF CORN AND SORGHUM

Since these smuts are not carried on the seed, disinfection of

*For details of this treatment see U. S. Dept. of Agriculture, Farmers' Bulletin 939: 21-24. 1918.

Fig. 6. (1) Tassel showing the usual effect of Head Smut; (2) Tassel showing sterility and proliferation; (3) A smutted ear showing the characteristic fibers; (4) Sterility and proliferation in the ear. (From Phytopathology 10:329. 1920).

the seed is of no value in their control. Certain sanitary and cultural practices should be emphasized:

Crop rotation should be practiced in order to escape infection from contaminated soil. Neither corn nor sorghum should follow each other in case head smut is present.

Burn smut masses. In regions in which corn smut is becoming prevalent it will probably pay to collect the smut masses previous to the liberation of the smut dust or spores and destroy them by burning.

Avoid contaminated fertilizer. Corn smut is thoroughly at home in the compost heap and increases in amount. If smutted corn fodder or stover is feed to cattle, the manure from the feed lot should not be put on ground that is to be planted to corn.

SEED DISINFECTION

Seed disinfection with fungicides may be accomplished by the sack, open tank, sprinkle or dry methods using either the formaldehyde or bluestone formulae. In the sack and open tank methods it will be necessary to provide either tubs, barrels, tanks or vats suited to the quantity of seed to be disinfected. The routine is as follows:

Sack Method.

1. Prepare the solution of the requisite kind and strength. (See page 17).
2. Put the seed to be treated in gunny sacks (½ to 1½ bu. according to size of treating vats).
3. Immerse the sacks in the treating solution lifting them up and down several times to insure a complete wetting of all the grain. Steep for the requisite time (5 minutes to 2 hours).
4. Remove the sacks and drain, allowing the excess of fungicide, to drain back into the treating tank.
5. If formaldehyde has been used, allow the grain to stand 12 to 24 hours in the wet sacks before seeding. If it is to be kept much longer it should be spread out to dry. Bluestone treated seed may be seeded at once or as soon as it will run in the seeder, or

it may be held for several days if temperatures are warm enough to prevent freezing and low enough to prevent sprouting in the sack.

Open Tank Method.

1. Prepare the solution of the requisite kind and strength, (See pgae 17).
2. Pour a convenient quantity of the seed into the treating vessel, stir thoroughly and carefully and skim off all chaff, weed seed, light seed or smut masses that float on the surface. Repeat the operation and again skim off whatever rises to the surface.
3. Drain out the treating solution and retain for further use.
4. Sack and seed at once or after standing for the specified time as indicated under the sack method.
   The open tank method is recommended for use if the seed grain contains large numbers of smut masses.

Sprinkle Method.

1. Prepare the solution of the requisite kind and strength.
2. Pile a convenient quantity of seed to be treated in a wagon-box, on granary floor or on a canvas in the open.
3. While shoveling over the seed sprinkle the seed with the fungicide using a common garden sprinkler. Continue the operation until the grain is thoroughly wet. This will require ½ to 1 gallon of the treating solution per bushel.
4. Spread out at once to dry if bluestone has been used or in formaldehyde treatments, cover with wet sacks or canvas for two hours to over night. Seed may then be sacked for use or spread out to dry.

Dry Method.

This is recommended for use of formaldehyde in the treatment of oats.

1. Prepare the solution of the requisite strength. Choose either (a) one part formaldehyde (commercial article) to one part of water or (b) one pint of formaldehyde to 10 gallons of water.
2. Pile a convenient quantity of grain on a canvas and shovel over while spraying the seed with the fungicide. Use one quart of (a) to 50 bu. of seed or one quart of (b) to each bushel. The strong solution may be conveniently applied with a mason jar atomizer or similar sprayer, one stroke of the piston giving enough for each shovelful, while the weaker solution may be

used to better advantage with a compressed air hand sprayer. The aim should be to secure a uniform distribution of the fungicide.

Fig. 7. Common corn smut

3. Cover with canvas for five hours if the strong formula has been used or for 12 hours if the weaker strength has been employed.

4. Uncover and aerate or plant at once. With the use of the (b) solution the seed may be sacked up at once and planted the next day if this procedure is more convenient.

Dusting Method.

This is recommended especially for the use of copper carbonate dust in the treatment of wheat for bunt or stinking smut. Success is dependent upon securing a uniform distribution of the dust over the grain to be protected. This dusting can best be accomplished by arranging a rotating barrel or box in which the seed and fungicide can be agitated.

FORMULAE

Plain Bluestone. The 1-5 or the 1-10 formula. One pound of bluestone (blue vitriol or copper sulphate) to 5 gallons of water. Use either the sack or open tank methods. With the stronger formula five minutes immerson is sufficient, but 10 minutes is more reliable for the weaker solution. The solution may be prepared by weighing the bluestone and measuring the water or by the use of a Brix sugar hydrometer. The hydrometer may be floated in the treating solution and the proper strength is reached when the reading at the surface of the solution is 4. This is the reading for the 1-5 formula.

Plain Bluestone. The 1-1 formula. One pound of bluestone to 1 gallon of water. This is used in the sprinkling method for wheat and is offered as a promising method of treatment for perventing smut in contaminated soils. Use ½ gallon to each bushel and dry at once.

Bluestone and Salt. The Sutton steep or the 1-1-5 formula. One pound of bluestone and one pound of common salt dissolved in five gallons of water. This is slightly more effective than the 1-5 formula. Half strength or the 1-1-10 formula is also effective especially for spring seeding.

Bordeaux. The 8-8-40 formula.

(a) Slack 8 lbs. quick lime in small quantity of water, and dilute to 20 gallons.

(b) Dissolve 8 lbs. of bluestone in 20 gallons of water.

(c) Mix equal quantities of (a) and (b).

(d) Steep in this mixture for 10 to 15 minutes. This treatment causes less seed injury than the other bluestone formulae.

Formaldehyde. This is a gas dissolved in water, the standard commercial strength being 37 percent. All recommended dilutions are based on this strength:

One pint to 40 gallons of water.	For sack, open tank or sprinkle methods.
One pint to 30 gallons of water.	
One pint to 10 gallons of water.	For spraying method.
One pint to 1 pint of water.	For spraying method.

Copper Carbonate. Powdered copper carbonate may be used by dusting over the surface of the grain at the rate of 2 oz. to each bushel of seed. This has been used with some success in Australia and California, and has given very promising results in Washington. It generally causes less seed injury than either bluestone or formaldehyde.

RECOMMENDED SEED DISINFECTION

Crop	Disease	Treatment	Formula	Method	Duration
Wheat	Bunt or stinking smut.	1. Bluestone	1-5 or 1-10	Sack or open tank.	5-10 minutes
		2. Bluestone	1-1*	Sprinkle	1-2 gal. per bu. Dry at once.
		3. Bluestone and salt.	1-1-5 or 1-1-10	Sack or open tank.	5-10 minutes
		4. Bordeaux	8-8-40	Open tank.	10 min. then dry.
		5. Formaldehyde.	1-40	Sack or open tank.	10 minutes
		6. Copper carbonate powder.	2 oz. per bushel	Dusting	
	Loose smut	Hot water	Not neccessary under Washington conditions		

For treatments 1, 3, and 5, the seed injury can be greatly reduced by either pre-soaking in water or the use of an after bath of lime (1 lb. lime to 10 gallons water). For 2, presoaking may be used to cut down seed injury.

Oats	Covered or Loose smut	Formaldehyde	1-40	Sack or open tank.	10 minutes
		Formaldehyde	1-10	Spray	Sack and seed next day.
		Formaldehyde	1 pt. to 1 pt. water	Spray	Cover 5 hrs. and seed at once or aerate.
Barley	Covered smut	Formaldehyde	1-40	Sack or open tank.	30 minutes.
	Loose smut	Hot water	Not necessary under Washington conditions		
Sorghum	Kernel smut	Formaldehyde	1-30	Sack or open tank.	1 hour.

*Recommended for trial for fall seeding only.

SEED INJURY

In the disinfection of seed there will always be a certain amount of injury to the treated seed. The amount of injury is variable and cannot be predicted beforehand for any given seed lot even though a standard treatment is employed. It should however, be the aim of the farmer to practice a method of treating and handling which will reduce the injury to a minimum.

A few of the practices that affect the amount of injury may be noted. The use of too strong solutions should be guarded against by using accurately weighed or measured quantities, and treating for periods specified (actual time, not by guess). The grain after treating should be so handled as to guard against heating, molding, or continued action of formaldehyde. Injury from formaldehyde will be greatly increased by seeding in a very dry soil and will generally be greater after treated seed has been dried and allowed to stand some days than it will be if seeded soon after treating.

Seed injury from either formaldehyde or bluestone treatments may be reduced to a minimum by either of two methods:

Lime Bath. Use the lime bath immediately after removing from the treating solution. The fungicide should be drained away and the grain dipped in the lime solution (1 lb. of lime slacked in small quantity of water and diluted to 10 gallons) for several minutes or

long enough to secure a thorough contact of all grains with the protecting solution. This is not neccessary in case Bordeaux has been used.

Fig 8. The loose smut of wheat caused by Ustilago tritici. (From Washington Exp. Station Bulletin 126).

Pre-soaking. Seed that is to be treated should be dipped in water for 10 minutes and then allowed to remain in the wet sacks for 6 to 12 hours, after which the disinfection may be carried out in the manner selected. This pre-soaking not only reduces the amount of injury but increases the effectiveness of the fungicidal treatment.

Since seed injury is to be expected it is always a commendable practice to make a germination test of grain where a large acreage is involved. A representative lot of seed should be treated according to the method selected and germination tests made to determine the rate of seeding, which should be increased in accordance with the reduction in germination per cent.

IMPORTANT REMINDERS

Treat all visibly smutted seed.

Use the open tank method for seed showing any considerable number of smut balls or masses.

Determine whether visibly clean wheat is really smutty, and whether disinfection is neccessary.

Formaldehyde may be used in either metal or wooden vessels or vats, bluestone in wooden vessels, only.

Do not guess at the strength of solutions. Be accurate.

Do not throw away treating solutions if they have been allowed to stand. They are effective until used up. This means formaldehyde as well as bluestone.

Do not put treated grain into dirty sacks.

Do not allow treated grain to freeze.

Do not allow formaldehyde-treated seed to stand over 12-24 hours in the sacks before seeding.

Seed formaldehyde-treated seed moist rather than allowing it to dry.

Do not seed formaldehyde-treated seed in the "dust."

Use one of the methods of reducing seed injury to the minimum.

Know your seed injury by actual germination tests and seed accordingly.